SP 55 (1993): Design Aid for Anchorages for Spillway Piers, Training Walls and Divide Walls [WRD 9: Dams and Spillways]

BLANK PAGE

अधिप्लव पोत घाटों ट्रेनिंग दीवारों और विभाजन दीवारों के लिये लंगर कार्यों के डिजाइन एड

DESIGN AID FOR ANCHORAGES FOR SPILLWAY PIERS, TRAINING WALLS AND DIVIDE WALLS

UDC 627·231·8 : 72·011

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

June 1993

Price Group 6

Spillwaps Including Energy Dissipators Sectional Committee, RVD 10

FOREWORD

This special publication gives a method for design of anchorages for spillway piers, training walls and devide walls by computing stresses transferred to the base block from the piers/walls (*see* IS 12720 : 1993 'Structural design of spillway training walls and divide walls — Criteria' and IS 13551 : 1992 'Structural design of spillway crest and pier — Criteria') with the help of suitable tables.

For the purpose of deciding whether a particular requirement of this special publication, is complied with, the final value, observed or calculated expressing the result of a test analysis, should be rounded off in accordance with IS 2 : 1960 'Rules for rounding of numerical values (*revised*)'. The number of significant places retained in the rounded of value should be the same as that of the specified value in this special publication.

ISBN 81-7061-040-0

DESIGN AID FOR ANCHORAGES FOR SPILLWAY PIERS, TRAINING WALLS AND DIVIDE WALLS

1 SCOPE

This Special Publication gives a method for the design of anchorages for spillway piers, training walls and divide walls with the help of tables.

2 METHOD ADOPTED FOR CALCULATION OF STRESSES

2.1 Due to loading on the wall the stresses developed would be transferred to the base block and diffusion of stresses into the base block is of considerable importance for determination of depth of anchorage of reinforcing bars. The wall may be an end wall (*see* Fig. 1) or central wall (*see* Fig. 2). The diffusion of stresses would be in the quarter infinite block or end wall, whereas it would be in the semi-infinite block for the central wall.

2.2 To obatain the stresses in the base block due to end wall, the following multiplication factors should be worked out:

$$\frac{F}{b}, \frac{P}{b} \quad \text{and} \quad \frac{M}{b^2}$$

where

F = shear force at the base of the wall,

P = normal force,

M = moment at the base of the wall, and

b = base width of the wall.

The horizontal stress σx, the vertical stress σy and shear stress τxy due to unit value of shear force F, moment M, and normal force P, are given in the Tables 1, 2 and 3 respectively for different values of $\frac{x}{b}$ and $\frac{y}{b}$ where x and y are the distances along horizontal and vertical axis from the origin as shown in Fig. 1.

2.3 To obtain the stresses in the base block due to central wall, the following multiplication factors should be worked out:

$$\frac{F}{b}, \frac{P}{b} \quad \text{and} \quad \frac{6M}{b^2}$$

The stresses due to unit value of shear force F, moment M and normal force P are given in the Tables 4, 5 and 6 respectively for different values of $\frac{x}{b}$ and $\frac{y}{b}$ where x and y are the distances along horizontal and vertical axis from the origin as shown in Fig. 2.

2.4 The actual horizontal and vertical stress should be obtained by multiplying the unit values given in the tables with corresponding multiplication factor.

2.5 For horizontal anchorage, σx distribution is plotted at different vertical sections and the total tensile force is calculated at each of these sections. The horizontal anchorage steel is provided for the maximum tensile force obtained at these vertical sections.

2.6 The vertical stresses in the base block would diminish as the depth increases. Hence, the vertical reinforcement in the wall may be continued up to the depth where the tensile stresses developed are within permissible limits.

2.7 Computations based on these tables for design of anchorages for a divide wall resting directly over the foundation rock are given in Annex A.

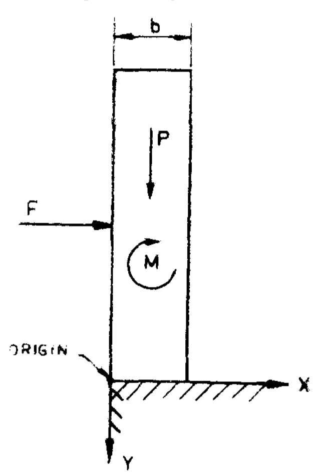


FIG. 1 END WALL

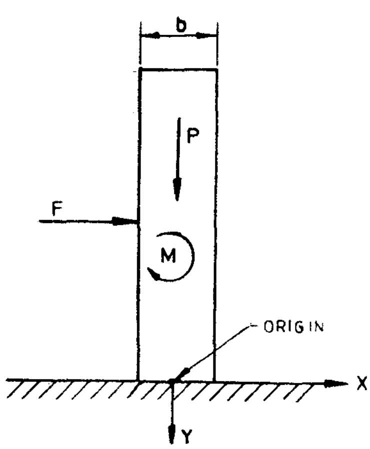
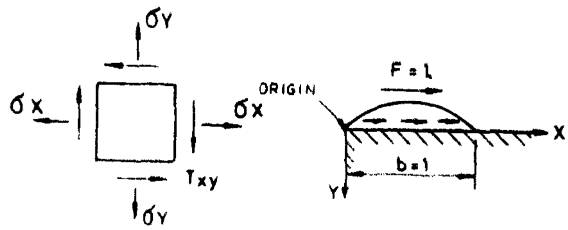


FIG. 2 CENTRAL WALL

Table 1 Stresses in End Wall Due to Unit Shear Force

(*Clause* 2.2)



y/b \ *x/b*	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00
0.00	0.00 0.00 0.00	0.19 0.00 1.13	1.50 0.00 1.50	2.80 0.00 1.13	2.87 0.00 0.00	1.97 0.00 0.00	1.53 0.00 0.00	1.26 0.00 0.00	1.07 0.00 0.00
0.25	0.00 −1.12 0.00	0.32 −0.51 0.46	0.96 0.00 0.71	1.35 0.27 0.58	1.47 0.28 0.46	1.37 0.12 0.35	1.20 0.06 0.25	1.07 0.03 0.18	0.96 0.03 0.13
0.50	0.00 −1.28 0.00	0.13 −0.64 0.06	0.45 0.00 0.23	0.64 0.92 0.34	0.80 0.32 0.42	0.87 0.22 0.39	0.88 0.15 0.32	0.84 0.09 0.26	0.80 0.07 0.21
0.75	0.00 −1.25 0.00	0.02 −0.77 −0.06	0.10 −0.20 0.02	0.25 0.13 0.16	0.40 0.26 0.27	0.52 0.24 0.31	0.59 0.19 0.31	0.62 0.14 0.27	0.62 0.11 0.24
1.00	0.00 −1.08 0.00	−0.01 −0.71 −0.09	0.02 −0.31 −0.06	0.08 0.02 0.04	0.18 0.17 0.15	0.29 0.21 0.22	0.38 0.19 0.24	0.44 0.16 0.25	0.46 0.13 0.23
1.25	0.00 −0.96 0.00	0.00 −0.67 −0.08	0.00 −0.35 −0.09	0.03 −0.08 −0.03	0.09 0.08 0.06	0.16 0.15 0.13	0.23 0.18 0.18	0.29 0.16 0.20	0.32 0.14 0.20
1.50	0.00 −0.87 0.00	0.00 −0.61 −0.08	−0.01 −0.37 −0.10	0.00 −0.15 −0.06	0.04 0.00 0.00	0.09 0.09 0.07	0.14 0.14 0.12	0.19 0.14 0.15	0.23 0.14 0.16
1.75	0.00 −0.77 0.00	−0.01 −0.57 −0.07	−0.02 −0.37 −0.09	−0.01 −0.19 −0.08	0.01 0.05 −0.03	0.03 0.04 0.02	0.08 0.10 0.07	0.12 0.11 0.11	0.15 0.12 0.13
2.00	0.00 −0.67 0.00	−0.01 −0.53 −0.07	−0.02 −0.37 −0.08	−0.02 −0.22 −0.08	−0.01 −0.09 −0.05	0.01 −0.01 0.00	0.03 0.06 0.03	0.07 0.08 0.08	0.10 0.09 0.10

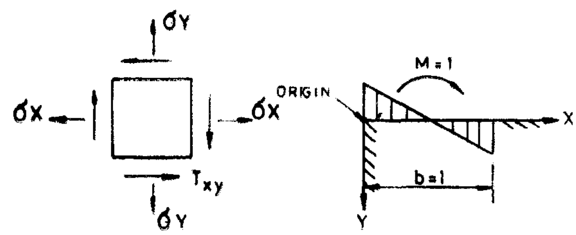
NOTES

1 The order of listing of the stresses σx, σy, τxy is $\begin{cases} \sigma x \\ \sigma y \\ \tau xy \end{cases}$.

2 The negative sign indicates tension and positive sign indicates compression.

Table 2 Stresses in End Wall Due to Unit Moment

(*Clause* 2.2)



y/b \ x/b	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00
0.00	0.00 -0.60 0.00	0.38 -3.00 0.00	1.79 0.00 0.00	3.84 3.00 0.00	3.33 6.00 0.00	1.00 0.00 0.00	0.60 0.00 0.00	0.50 0.00 0.00	0.50 0.00 0.00
0.25	0.00 -5.10 0.00	0.38 -2.69 -0.73	0.83 0.13 -0.91	0.90 2.37 -0.43	0.91 1.50 0.50	1.00 0.38 0.28	0.94 0.13 0.27	0.64 0.09 0.22	0.45 0.04 0.13
0.50	0.00 -3.71 0.00	-0.10 -2.24 -0.94	-0.19 -0.19 -0.97	-0.20 0.14 -0.42	0.07 1.34 0.37	0.37 0.69 0.60	0.43 0.27 0.38	0.39 0.12 0.26	0.40 0.08 0.21
0.75	0.00 -2.43 0.00	-0.26 -1.86 -0.72	-0.45 -0.38 -0.90	-0.51 0.77 -0.45	-0.30 0.97 0.03	0.02 0.73 0.48	0.17 0.37 0.34	0.24 0.20 0.27	0.19 0.14 0.22
1.00	0.00 -1.66 0.00	-0.12 -1.34 -0.50	-0.32 -0.51 -0.70	-0.47 0.32 -0.53	-0.37 0.53 -0.13	-0.27 0.50 0.22	-0.04 0.40 0.24	0.01 0.18 0.20	0.06 0.18 0.19
1.25	0.00 -1.28 0.00	-0.01 -0.94 -0.35	-0.18 -0.49 -0.55	-0.35 0.10 -0.34	-0.38 0.33 -0.12	-0.28 0.38 0.03	-0.20 0.29 0.09	-0.10 0.24 0.13	-0.09 0.13 0.11
1.50	0.00 -0.89 0.00	-0.07 -0.69 -0.27	-0.15 -0.37 -0.38	-0.31 -0.11 -0.33	-0.20 0.16 -0.19	-0.29 0.20 -0.10	-0.20 0.22 0.00	-0.10 0.15 0.03	-0.09 0.18 0.09
1.75	0.00 -0.65 0.00	0.02 -0.52 -0.16	0.01 -0.33 -0.26	-0.14 -0.18 -0.27	-0.30 -0.07 -0.21	-0.30 0.10 -0.14	-0.27 0.21 -0.09	-0.16 0.16 0.00	-0.12 0.15 0.04
2.00	0.00 -0.50 0.00	-0.02 -0.46 -0.12	-0.08 -0.34 -0.20	-0.14 -0.20 -0.22	-0.18 -0.06 -0.19	-0.19 -0.01 -0.17	-0.18 0.09 -0.09	-0.16 0.12 -0.04	-0.12 0.12 0.00

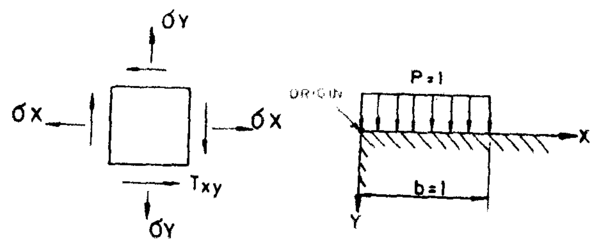
NOTES

1 The order of listing of the stresses σx, σy, τxy is $\left\{ \begin{array}{l} \sigma x \\ \sigma y \\ \tau xy \end{array} \right.$

2 The negative sign indicates tension and positive sign indicates compression.

Table 3 Stresses in End Wall Due to Unit Normal Force

(Clause 2.2)



y/b \ x/b	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00
0.00	0.00 1.00 0.00	0.03 1.00 0.00	0.07 1.00 0.00	0.13 1.00 0.00	−0.25 1.00 0.00	−0.57 0.00 0.00	−0.46 0.00 0.00	−0.45 0.00 0.00	−0.43 0.00 0.00
0.25	0.00 1.00 0.00	0.03 1.10 0.00	0.03 0.93 0.02	0.06 0.90 0.08	−0.06 0.56 0.13	−0.19 0.04 0.08	−0.26 0.02 0.03	−0.29 0.06 0.00	−0.30 0.00 -0.01
0.50	0.00 1.10 0.00	0.02 0.96 −0.02	0.01 0.90 0.05	0.00 0.88 0.10	−0.03 0.43 0.24	−0.09 0.14 0.16	−0.14 0.07 0.08	−0.17 0.03 0.03	−0.20 0.02 0.01
0.75	0.00 1.15 0.00	0.00 0.83 −0.02	−0.06 0.85 0.06	−0.06 0.77 0.17	−0.08 0.45 0.22	−0.05 0:23 0.18	−0.07 0.13 0.11	−0.09 0.07 0.06	−0.12 0.04 0.03
1.00	0.00 1.28 0.00	−0.06 0.83 0.03	−0.09 0.74 0.07	−0.04 0.61 0.16	−0.03 0.44 0.19	−0.03 0.29 0.17	−0.03 0.18 0.12	0.04 0.11 −0.08	−0.06 0.07 0.05
1.25	0.00 1.07 0.00	−0.07 0.88 0.07	−0.06 0.74 0.104	−0.036 0.59 0.13	−0.02 0.45 0.17	−0.004 0.32 0.16	0.00 0.21 0.13	−0.01 0.14 0.10	−0.02 0.09 0.07
1.50	0.00 0.98 0.00	0.00 0.83 0.07	−0.003 0.70 0.11	−0.01 0.57 0.14	0.01 0.44 0.15	0.02 0.33 0.15	0.02 0.28 0.13	0.01 0.17 0.11	0.01 0.12 0.08
1.75	0.00 0.90 0.00	0.00 0.75 0.07	0.01 0.66 0.11	0.02 0.55 0.13	−0.02 0.44 0.15	0.03 0.34 0.14	0.03 0.26 0.13	0.03 0.19 0.11	0.02 0.14 0.09
2.00	0.00 0.82 0.00	0.00 0.73 0.06	0.01 0.63 0.10	0.02 0.53 −0.13	0.03 0.44 0.14	0.035 0.35 0.14	0.04 0.27 0.13	0.04 0.21 0.11	0.04 0.16 0.10

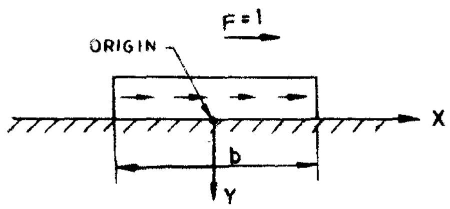
NOTES

1 The order of listing of the stresses σx, σy, τxy is $\begin{cases} \sigma x \\ \sigma y \\ \tau xy \end{cases}$

2 The negative sign indicates tension and positive sign indicates compression.

Table 4 Stresses in Central Wall Due to Unit Shear Force

(Clause 2.3)



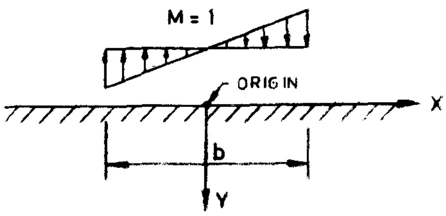
y/b \ x/b	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	Stresses
	0.000 0	0.699 4	2.925 0*	1.024 6	0.699 4	0.539 4	0.441 3	0.374 2	0.325 2	σx
0.00	0.000 0	0.000 0	0.000 0	0.000 0	00.000 0	0.000 0	0.000	0.000 0	0.000 0	σy
	-1.000 0	-1.000 0	-1.000 0	00.000	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	τxy
	0.000 0	0.385 0	0.602 3	0.669 5	0.582 0	0.486 8	0.413 1	0.357 3	0.314 2	σx
0.25	0.000 0	0.127 3	0.299 6	0.146 9	0.055 1	0.025 5	0.013 8	0.008 4	0.005 5	σy
	-0.450 2	-0.392 9	-0.347 1	-0.285 1	-0.170 7	-0.108 2	-0.074 1	-0.053 9	-0.040 9	τxy
	0.000 0	0.147 4	0.257 7	0.348 8	0.385 0	0.373 4	0.344 6	0.313 4	0.284 6	σx
0.50	0.000 0	0.156 7	0.254 6	0.210 7	0.127 3	0.073 9	0.044 9	0.028 9	0.019 6	σy
	-0.181 7	-0.186 2	-0.225 1	-0.248 9	-0.211 2	-0.161 4	-0.122 0	-0.093 9	-0.073 9	τxy
	0.000 0	0.059 8	0.121 5	0.187 3	0.238 5	0.262 7	0.265 7	0.257 4	0.244 2	σx
0.75	0.000 0	0.127 3	0.203 7	0.202 2	0.156 7	0.109 8	0.075 3	0.052 4	0.037 4	σy
	-0.080 5	-0.097 8	-0.142 4	-0.180 6	-0.184 8	-0.165 0	-0.138 8	-0.114 5	-0.094 5	τxy
	0.000 0	0.026 9	0.061 5	0.101 9	0.147 4	0.178 8	0.196 2	0.202 4	0.201 4	σx
1.00	0.000 0	0.095 9	0.159 2	0.175 4	0.156 7	0.125 4	0.095 5	0.071 7	0.054 0	σy
	-0.040 5	-0.055 1	-0.090 8	-0.126 9	-0.145 7	-0.145 6	-0.134 2	-0.118 8	-0.103 2	τxy
	0.000 0	0.013 4	0.033 2	0.061 2	0.092 7	0.121 0	0.142 0	0.155 1	0.161 6	σx
1.25	0.000 0	0.072 0	0.124 2	0.146 9	0.144 0	0.126 5	0.104 7	0.084 1	0.066 8	σy
	-0.022 7	-0.033 2	-0.059 5	-0.089 2	-0.111 0	-0.120 4	-0.119 6	-0.112 6	-0.102 8	τxy
	0.000 0	0.007 2	0.019 1	0.037 3	0.059 8	0.082 6	0.102 4	0.117 4	0.127 5	σx
1.50	0.000 0	0.055 1	0.097 9	0.121 9	0.127 3	0.119 8	0.105 8	0.089 9	0.074 9	σy
	-0.013 8	-0.021 2	-0.040 3	-0.063 6	-0.083 9	-0.096 9	-0.102 1	-0.101 3	-0.096 7	τxy
	0.000 0	0.004 2	0.011 6	0.023 6	0.039 6	0.057 2	0.074 1	0.088 6	0.099 8	σx
1.75	0.000 0	0.043 0	0.078 4	0.010 12	0.110 8	0.109 8	0.101 9	0.090 8	0.078 8	σy
	-0.009 0	-0.014 2	-0.028 1	-0.046 3	-0.063 8	-0.077 2	-0.085 3	0.088 4	-0.087 8	τxy
	0.000 0	0.002 6	0.007 4	0.015 5	0.026 9	0.040 3	0.054 1	0.067 0	0.078 0	σx
2.00	0.000 0	0.034 3	0.063 7	0.084 5	0.095 9	0.098 8	0.095 5	0.088 4	0.079 5	σy
	-0.006 2	-0.010 0	-0.020 3	-0.034 3	-0.049 0	-0.061 5	-0.070 6	-0.075 9	-0.077 9	τxy

* at x/b = 0.49 and y/b = 0

Note — Positive sign indicates compressive stresses and negative sign indicates tensile stresses.

Table 5 Stresses in Central Wall Due to Unit Moment

(*Clause* 2.3)

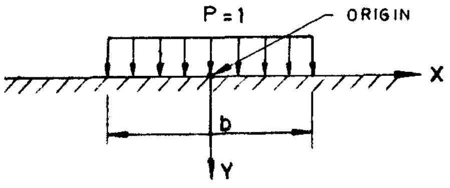


y/b \ x/b	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	Stresses
0.00	0.000 0	+0.500 0	1.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	σx
	0.000 0	+0.500 0	1.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	σy
	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	τxy
0.25	0.000 0	0.004 0	0.046 0	0.092 9	0.050 4	0.027 0	0.015 8	0.010 0	0.006 7	σx
	0.000 0	0.387 5	0.347 1	0.060 4	0.011 1	0.003 1	0.001 1	0.000 5	0.000 2	σy
	0.225 1	0.132 8	−0.126 0	−0.077 8	−0.024 8	−0.009 6	−0.004 4	−0.002 3	−0.001 3	τxy
0.50	0.000 0	−0.054 4	−0.032 6	0.024 5	0.037 5	0.030 1	0.021 5	0.015 2	0.010 9	σx
	0.000 0	0.210 6	0.225 1	0.109 9	0.040 5	0.015 5	0.006 6	0.003 1	0.001 6	σy
	0.181 7	0.107 8	−0.029 6	−0.067 3	−0.043 4	−0.023 4	−0.012 8	−0.007 4	−0.004 5	τxy
0.75	0.000 0	−0.040 8	−0.039 8	−0.010 0	−0.011 9	0.018 5	0.017 7	0.014 8	0.011 8	σx
	0.000 0	0.112 5	0.142 4	0.102 4	0.056 3	0.028 4	0.014 5	0.007 7	0.004 3	σy
	0.120 8	0.083 0	0.009 8	−0.032 4	−0.036 2	−0.026 9	−0.017 9	−0.011 7	−0.007 7	τxy
1.00	0.000 0	−0.026 2	−0.032 1	−0.019 4	−0.003 6	−0.006 4	0.010 4	0.011 0	0.010 1	σx
	0.000 0	0.063 5	0.090 8	0.080 7	0.056 3	0.034 9	0.020 8	0.012 4	0.007 5	σy
	0.081 0	0.062 3	0.022 5	0.009 3	−0.022 1	−0.022 2	−0.018 0	−0.013 4	0.009 8	τxy
1.25	0.000 0	−0.016 8	−0.023 6	−0.019 3	0.009 9	−0.001 5	0.003 8	0.006 4	0.007 2	σx
	0.000 0	0.038 2	0.059 5	0.060 4	0.049 2	0.035 4	0.023 9	0.015 8	0.010 4	σy
	0.056 8	0.047 0	0.024 5	0.002 7	−0.010 5	−0.015 2	−0.015 0	−0.012 8	−0.010 2	τxy
1.50	0.000 0	−0.011 1	−0.017 1	−0.016 4	−0.011 5	−0.005 6	−0.000 8	0.002 4	0.004 2	σx
	0.000 0	0.024 4	0.040 3	0.044 7	0.040 5	0.032 5	0.024 3	0.017 5	0.012 3	σy
	0.041 5	0.036 1	0.022 8	0.008 2	−0.002 9	−0.008 9	−0.011 0	−0.010 7	−0.009 5	τxy
1.75	0.000 0	−0.007 6	−0.012 4	−0.013 3	−0.010 9	−0.007 2	−0.003 4	−0.000 4	−0.001 6	σx
	0.000 0	0.016 3	0.028 1	0.033 3	0.032 6	0.028 4	0.023 0	0.017 7	0.013 3	σy
	0.031 5	0.028 3	0.020 1	0.010 2	0.001 6	−0.004 2	0.007 2	−0.008 2	−0.008 0	τxy
2.00	0.000 0	−0.005 4	−0.009 2	−0.010 5	−0.009 6	−0.007 4	−0.004 7	−0.002 2	−0.000 2	σx
	0.000 0	0.011 4	0.020 3	0.025 1	0.026 0	0.024 1	0.020 8	0.017 0	0.013 5	σy
	0.024 7	0.022 7	0.017 4	0.010 6	0.004 1	−0.000 9	−0.004 1	−0.005 8	−0.006 4	τxy

NOTE — Positive sign indicates compressive stresses and negative sign indicates tensile stresses.

Table 6 Stresses in Central Wall Due to Unit Normal Force

(*Clause* 2.3)



y/b \ *x/b*	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	Stresses
	+1.000 0	+1.000 0	1.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	σx
0.00	+1.000 0	+1.000 0	1.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	σy
	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	0.000 0	τxy
	0.450 2	0.392 9	0.347 1	0.285 1	0.170 7	0.108 2	0.074 1	0.053 9	0.040 9	σx
0.25	0.959 5	0.902 2	0.496 9	0.089 2	0.019 3	0.006 3	0.002 7	0.001 3	0.000 7	σy
	0.000 0	−0.127 3	−0.299 6	−0.146 9	−0.055 1	−0.025 5	−0.013 8	−0.008 4	−0.005 5	τxy
	0.181 7	0.186 2	0.225 1	0.248 9	0.211 2	0.161 4	0.122 0	0.093 9	0.073 9	σx
0.50	0.818 3	0.734 7	0.479 7	0.213 7	0.083 9	0.035 8	0.017 2	0.009 2	0.005 3	σy
	0.000 0	−0.156 7	−0.254 6	−0.210 7	−0.127 3	−0.073 9	−0.044 9	−0.028 9	−0.019 6	τxy
	0.080 5	0.097 8	0.142 4	0.180 6	0.184 8	0.165 0	0.138 8	0.114 5	0.094 5	σx
0.75	0.668 2	0.607 1	0.448 0	0.270 5	0.145 7	0.077 2	0.042 5	0.021 7	0.015 1	σy
	0.000 0	−0.127 3	−0.203 7	−0.202 2	−0.156 7	−0.109 8	−0.075 3	−0.052 4	−0.037 4	τxy
	0.040 5	0.055 1	0.090 8	0.126 9	0.145 7	0.145 6	0.134 2	0.118 8	0.103 2	σx
1.00	0.549 8	0.510 5	0.409 2	0.287 6	0.184 8	0.114 2	0.070 6	0.044 5	0.028 9	σy
	0.000 0	−0.095 9	−0.159 2	−0.175 4	−0.156 7	−0.125 4	−0.095 5	−0.071 7	−0.054 0	τxy
	0.022 7	0.033 2	0.059 5	0.089 2	0.111 0	0.120 4	0.119 6	0.112 6	0.102 8	σx
1.25	0.461 8	0.436 5	0.370 0	0.285 1	0.204 5	0.140 7	0.095 2	0.064 6	0.044 3	σy
	0.000 0	−0.072 0	−0.124 2	−0.146 9	−0.144 0	−0.126 5	−0.104 7	−0.084 1	−0.066 8	τxy
	0.013 8	0.021 2	0.040 3	0.063 6	0.083 9	0.096 9	0.102 1	0.101 3	0.096 7	σx
1.50	0.395 8	0.379 1	0.334 1	0.273 5	0.211 2	0.156 8	0.113 9	0.082 1	0.059 3	σy
	0.000 0	−0.055 1	−0.097 9	−0.121 9	−0.127 3	−0.119 8	−0.105 8	−0.089 9	−0.074 9	τxy
	0.009 0	0.014 2	0.028 1	0.046 3	0.063 8	0.077 2	0.085 3	0.088 4	0.087 8	σx
1.75	0.345 3	0.333 9	0.302 4	0.258 3	0.210 2	0.165 0	0.126 6	0.095 9	0.072 3	σy
	0.000 0	−0.043 0	−0.078 4	−0.101 2	−0.110 8	−0.109 8	−0.101 9	−0.090 8	−0.078 8	τxy
	0.006 2	0.010 0	0.020 3	0.034 3	0.049 0	0.061 5	0.070 6	0.075 9	0.077 9	σx
2.00	0.305 8	0.297 6	0.274 6	0.242 1	0.204 7	0.167 7	0.134 2	0.105 9	0.082 9	σy
	0.000 0	−0.034 3	−0.063 7	−0.084 5	−0.095 9	−0.098 8	−0.095 5	−0.088 4	−0.079 5	τxy

NOTE — Positive sign indicates compressive stresses and negative sign indicates tensile stresses.

ANNEX A

(*Clause* 2.7)

COMPUTATIONS FOR DESIGN OF ANCHORAGE REINFORCEMENT FOR A DIVIDE WALL (*see* Fig. 3)

Given :

1. Base width of wall = 2.5 m
2. Direct load per m run = 72 t
3. Shear force per metre run = 50 t
4. Bending moment per metre run = 166.667 t.m
5. Vertical reinforcement in wall on either face for direct load and moment = 25 mm deformed bars conforming to IS 1786 : 1985 @ 140 mm c/c
6. Concrete mix used = *M* 20
7. Permissible tensile stress in steel = 80% of 2.300 t/cm^2 = 1.84 t/cm^2
8. Allowable tensile stress in concrete = 1% of compressive strength of concrete = 0.01 × 2 000 = 20 t/m^2
9. Allowable tensile stress of fresh rock = 20 t/m^2 (assumed same as concrete in this example. For permissible stresses relevant Indian Standard be referred to)
10. The anchorages for the divide wall are to be designed for loading on one side and with no water on other side and *vice/versa*.

As there is concrete slab on both sides of the wall, therefore, semi-plate infinite theory (*see* **2.3**) should be used to calculate horizontal anchorage and the depth up to which the vertical reinforcement bars should be taken to.

Here

Direct load per metre run

$$P = 72 \text{ t.}$$

Shear force per metre run

$$F = -50 \text{ t.}$$

Bending moment per metre run

$$M = -166.667 \text{ t.m}$$

Multiplication Factors

$$\frac{P}{b} = \frac{72}{2.5} = 28.80 \text{ t/m}^2$$

$$\frac{E}{b} = \frac{-50}{2.5} = -20.0 \text{ t/m}^2$$

$$\frac{6\,M}{b^2} = \frac{-6 \times 166.667}{(2.5)^2} = -160.00 \text{ t/m}^2$$

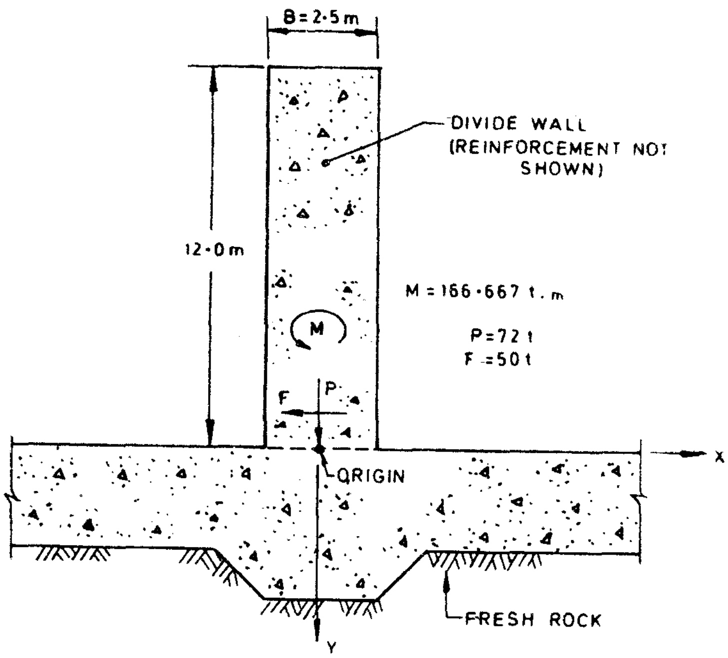


FIG. 3 DESIGN OF A DIVIDE WALL

Total horizontal and vertical stresses at different points calculated on the basis of different tables are indicated in Table 7 and 8 respectively.

Design of Horizontal Anchorage

For design of horizontal anchorage horizontal stresses on vertical planes should be considered. Table 7 (indicating the value of σx) is referred to:

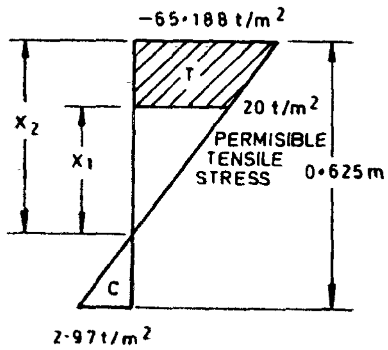
i) At x/b = 0.25

Here

$$\frac{65.188}{x_2} = \frac{2.97}{0.625 - x_2}$$

$$\text{or } x_2 = \frac{65.188 \times 0.625}{65.188 + 2.97}$$

$$= 0.598 \text{ m}$$



Also

$$\frac{65.188}{0.598} = \frac{20}{x_1} \quad \text{or } x_1 = 0.18 \text{ m}$$

Total tensile force (hatched area)

$$= \frac{(65.188 + 20)}{2} \times (0.598 - 0.18)$$

= 17.8 t/m-run

ii) At x/b = 0.50

Here

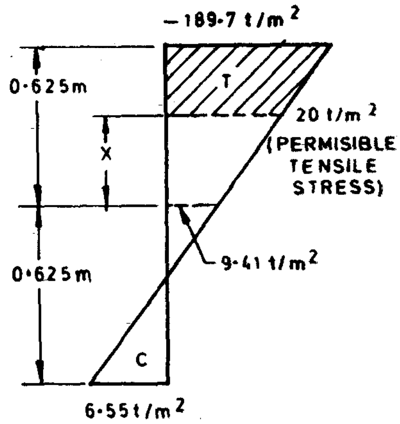
$$\frac{(189.70 - 9.41)}{0.625} = \frac{(20 - 9.41)}{x}$$

or x = 0.036 7 m

Total tensile force (hatched area)

$$= \frac{(189.7 + 20)}{2} \times (0.625 - 0.036\ 7)$$

= 61.68 t/m-run



iii) At x/b = 0.75

From Table 7 it may be seen that the maximum tensile stress at this section is 20.4 t/m^2 which is approximately equal to the permissible tensile stress 20 t/m^2, hence no reinforcement is required at this section.

From the above it is seen that maximum horizontal tensile force is:

= 61.68 t/m-run

Area of steel required

$$= \frac{61.88}{1.84} = 33.5 \text{ cm}^2$$

Provided 25 mm deformed steel bars @ 140 mm c/c

The length on either side of the divide wall up to which horizontal anchorage reinforcement to be provided is determined in the following manner :

i) At x/b = 0.5 (face of the wall)

Anchorage length required = 45 d = 45 x 25 = 1 125 mm

= 1.125 m from the face of the wall.

ii) At x/b = 0.75 maximum tensile stress is equal to 20.49 t/m^2, which is very close to the tensile stress of 20 t/m^2 for the mix used. The steel rods are not under tension here.

Reinfrocement is required up to a length equal to 12 d beyond this point, that is, 12 × 25 = 300 mm = 0.30 m or 0.625 + 0.30 = 0.925 m from the face of the wall. Hence provide horizontal anchorage up to 1.125 m (1.20 m say) from the face of the wall.

Design of Vertical Anchorage

For design of the depth of vertical anchorage Table 8 should be used.

It is seen that for a permissible tensile stress of 20 t/m^2, a depth of 0.75 b (width of divide wall) should be sufficient (In table 8 at x/b = 0.5 and y/b = 0.75; σy is only 13.9 t/m^2 tensile). However, vertical anchorage may be provided for a minimum depth equal to thickness of the divide wall, that is, 2.5 m.

Reinforcement details are shown in Fig. 4.

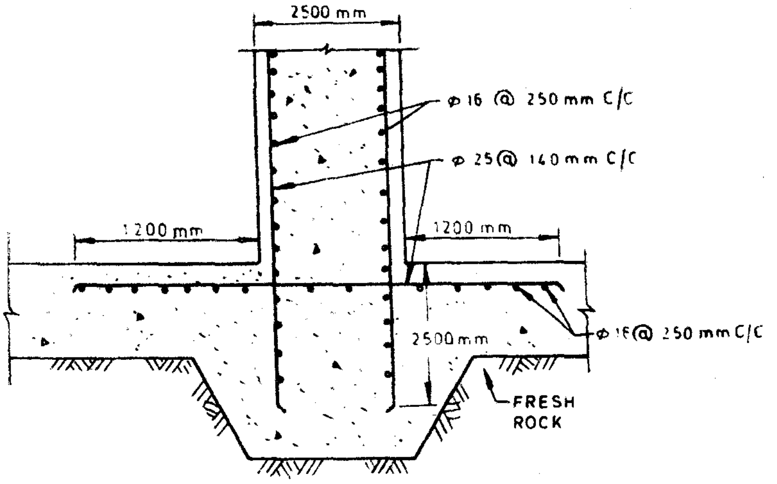


FIG. 4 TYPICAL REINFORCEMENT DETAILS OF ANCHORAGE

Table 7 Computation of Horizontal Stress (σx) at Different Points

(*Annex* A)

$$\frac{F}{b} = \frac{-50}{2.5} = -20.0\ \text{t/m}^2$$

$$\frac{P}{b} = \frac{72}{2.5} = 28.8\ \text{t/m}^2$$

$$\frac{6M}{b^2} = \frac{-6 \times 166.67}{2.5^2} = -160.0\ \text{t/m}^2$$

y/b \ x/b	Contribution of σx Due to	0.00		0.25		0.50		0.75		1.00		1.25		1.50		1.75		2.00	
		Coeff	σx	Coeff	σx	Coeff	σx	Coeff	σx	Coeff	σx	Coeff	σx	Coeff	σx	Coeff	σx	Coeff	σx
0.00	Shear Force	0.00	0.00	0.6994	(–)13.988	2.925	(–)58.5	1.0246	(–)20.492	0.6994	(–)13.988	0.539 4	(–)10.788	0.441 3	(–)8.826	0.374 2	(–)7.484	0.325 2	(–)6.504
	Direct Load	1.00	28.8	1.00	28.8	1.00	28.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Moment	0.0	0.0	0.50	(–)80.0	1.00	(–)160.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total		28.8		(–)65.188		(–)189.70		(–)20.492		(–)13.988		(–)10.788		(–)8.826		(–)7.484		(–)6.504
0.25	Shear Force	0.0	0.0	0.385	(–)7.7	0.602 3	(–)12.046	0.669 5	(–)13.35	0.582	(–)11.64	0.486 8	(–)9.736	0.413 1	(–)8.262	0.357 3	(–)7.146	0.314 2	(–)5.284
	Direct Load	0.450 2	12.965 8	0.392 9	11.316	0.347 1	9.996	0.285 1	8.211	0.170 7	4.916 2	0.108 2	3.116 1	0.074 1	2.134 1	0.053 9	1.552 3	0.040 9	1.177 9
	Moment	0.0	0.0	0.004	(–)0.64	0.046	(–)7.36	0.092 9	(–)14.864	0.0504	(–)8.064	0.027	(–)4.32	0.015 8	(–)2.528	0.01	(–)1.600	0.006 7	(–)1.072
	Total		12.965 8		2.975 5		(–)9.41		(–)20.000		(–)14.787 8		(–)10.94		(–)8.656		(–)7.193 7		(–)6.183 1
0.50	Shear Force	0.00	0.0	0.147 4	(–)2.948	0.257 7	(–)5.154	0.348 8	(–)6.976	0.385 0	(–)7.70	0.3 734	7.468	0.344 6	(–)6.892	0.313 4	(–)6.268	0.284 6	(–)5.60
	Direct Load	0.181 7	5.233 0	0.186 2	5.362 6	0.225 1	6.482 8	0.248 9	7.168 3	0.211 2	6.082 6	0.1 614	4.648 3	0.122 0	3.513 6	0.093 9	2.704	0.073 9	2.128 3
	Moment	0.000	0.0	(–)0.054 4	(+)8.704	(–)0.032 6	(+)5.216	0.024 5	(–)3.92	0.037 5	(–)6.0	0.0 301	(–)4.816	0.021 5	(–)3.44	0.015 2	(–)2.432	0.010 9	(–)1.744
	Total		5.233 0		11.118 6		6.544 8		(–)3.727 7		(–)7.617 4		(–)7.635 7		(–)6.818		(–)5.996		(–)5.125 7
0.75	Shear Force	0.00	0.0	0.0598	(–)11.96	0.121 5	(–)2.43	0.187 3	(–)3.746	0.238 5	(–)4.77	0.262 7	(–)5.254	0.265 7	(–)5.394	0.257 4	(–)5.148	0.244 2	(–)4.884
	Direct Load	0.080 5	2.318 4	0.097 8	28.166	0.142 4	4.101	0.180 6	5.201 3	0.184 8	5.322 2	0.165 0	4.752	0.138 8	3.997 4	0.114 5	3.297 6	0.094 5	2.721 6
	Moment	0.000	0.00	(–)0.040 8	(+)6.528	(–)0.039 8	(+)6.368	(–)0.010 0	(+)1.600	(–)0.011 9	(+)1.904	0.018 5	(–)2.96	0.017 7	(–)2.832	0.014 8	(–)2.368	0.011 8	(–)1.888
	Total		2.3184		22.734		8.039		3.055 3		2.456 2		(–)3.462		(–)4.228 6		(–)4.218 4		(–)4.050 4
1.00	Shear Force	0.00	0.0	0.026 9	(–)0.538	0.061 5	(–)1.23	0.104 9	(–)2.098	0.147 4	2.948	0.178 8	(–)3.576	0.196 2	(–)3.924	0.202 4	(–)4.048	0.201 4	(–)4.029
	Direct Load	0.040 5	1.166 4	0.055 1	1.586	0.090 8	2.615	0.126 9	3.654 7	0.145 7	4.196 2	0.145 6	4.193 2	0.134 2	3.864 9	0.118 8	3.241 4	0.103 2	2.972 1
	Moment	0.000	0.0	(–)0.026 2	(+)4.192 0	(–)0.032 1	5.136	(–)0.019 4	(+)3.104	(–)0.003 6	0.576	(–)0.006 4	(+)1.024	0.010 4	(–)1.664	0.011 0	(–)1.76	0.010 1	(–)1.616
	Total		1.166 4		5.24		6.521		4.660 7		1.824 2		1.641 2		(–)1.723 1		(–)2.386 6		(–)2.671 9
1.25	Shear Force	0.00	0.00	0.013 4	(–)0.268	0.033 2	(–)0.644	0.061 2	(–)1.224	0.092 7	(–)1.859	0.121	(–)2.420	0.142 0	(–)2.84	0.155 1	(–)3.102	0.161 6	(–)3.232
	Direct Load	0.022 7	0.653 7	0.033 2	0.956	0.059 5	1.713 6	0.089 2	2.568 9	0.111 0	3.968	0.120 4	3.467 5	0.119 6	3.444	0.112 6	3.242 8	0.102 8	2.960 6
	Moment	0.000	0.0	(–)0.016 8	(+)2.688	(–)0.023 6	(+)3.776	(–)0.019 3	3.088	(–)0.009 9	(+)1.584	(–)0.001 5	(+)0.24	0.003 8	(–)0.608	0.006 4	(–)1.024	0.007 2	(–)1.152
	Total		0.653 7		(+)3.376		4.825 6	(–)0.019 3	4.432 9		(–)0.241 2		1.287 5		(–)0.004		(–)0.883 1		(–)1.423
1.50	Shear Force	0.000	0.0	0.007 2	(–)0.144	0.019 1	(–)0.382	0.037 3	(–)0.746	0.059 8	(–)1.196	0.082 6	(–)1.651	0.102 4	(–)2.048	0.117 4	(–)2.348	0.127 5	(–)2.55
	Direct Load	0.013 8	0.397 4	0.021 2	0.610 5	0.040 3	1.160 6	0.063 6	1.831 6	0.083 9	2.416 3	0.096 9	2.790 7	0.102 1	2.94	0.101 3	2.917 4	0.096 7	2.784 9
	Moment	0.00	0.0	(–)0.011 1	(+)1.776	(–)0.017	(+)2.736	(–)0.0164	(+)2.624	(–)0.011 5	(+)1.84	(–)0.005 6	(+)0.896	(–)0.000 8	(+)0.128	0.002 4	(–)0.384	0.004 2	(–)0.672
	Total		0.397 4		(+)2.242 5		3.514 6		3.709 6		3.060 3		2.034 7		1.02		0.185 4		(–)0.437 1
1.75	Shear Force	0.000	0.0	0.004 2	(–)0.084	0.011 6	(–)0.232	0.023 6	(–)0.472	0.039 6	(–)0.792	0.057 2	1.144	0.074 1	(–)1.482	0.088 6	(–)1.772	0.099 8	(–)1.996
	Direct Load	0.009 0	2.592	0.014 2	0.408 9	0.028 1	0.809 2	0.046 3	1.333	0.063 8	1.837	0.077 2	2.223	0.085 3	2.456 6	0.088 4	2.545 9	0.087 8	2.528 6
	Moment	0.000	0.0	(–)0.007 6	1.216	(–)0.0124	(+)1.984	(–)0.013 3	(+)2.128	(–)0.010 9	(–)1.744	(–)0.007 2	(+)1.152	(–)0.003 4	(+)0.540	(–)0.000 4	(+)0.064	0.001 6	(–)0.256
	Total		2.592		1.540 9		2.561 2		2.989		2.789		2.231		1.518 6		0.837 9		0.276 6
2.00	Shear Force	0.000 0	0.000	0.002 6	(–)0.052	0.007 4	(–)0.148	0.015 5	(–)0.31	0.026 9	(–)0.538	0.040 3	(–)0.806	0.054 1	(–)1.082	0.067 0	(–)1.34	0.078	(–)1.56
	Direct Load	0.006 2	0.178 6	0.010 0	0.288	0.020 3	0.584 6	0.034 3	0.987 8	0.049 0	1.411 2	0.061 5	1.771 2	0.070 6	2.032 3	0.075 9	2.185 9	0.077 9	2.243 5
	Moment	0.000 0	0.00	(–)0.005 4	(+)0.864	(–)0.009 2	(+)1.472	(–)0.010 5	(–)1.68	(–)0.009 6	(+)1.536	(–)0.007 4	(+)1.184	(–)0.004 7	(+)0.752	(–)0.002 2	(–)0.352	0.000 2	0.032
	Total		0.178 6		1.100		1.908 6		2.357 8		2.409 2		2.149 2		1.702 3		1.197 9		0.715 5

Sign Convention : (–) = Tensile stresses.

(+) = Compressive stresses.

Table 8 Computation of Vertical Stress (σy) at Different Points

(*Annex* A)

$$\frac{F}{b} = \frac{-50}{2.5} = -20.0 \text{ t/m}^2$$

$$\frac{P}{b} = \frac{72}{2.5} = 28.8 \text{ t/m}^2$$

$$\frac{6M}{b^2} = \frac{-6 \times 166.667}{2.5^2} = -160.0 \text{ t/m}^2$$

x/b / y/b	Contribution of σy Due to	0.00		0.25		0.50		0.75		1.00		1.25		1.50		1.75		2.00	
		Coeff	σx	Coeff	σx	Coeff	σx	Coeff	σx	Coeff	σx	Coeff	σx	Coeff	σx	Coeff	σx	Coeff	σx
0.00	Shear Force	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Direct Load	1.00	28.8	1.00	28.80	1.00	28.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Moment	0.00	0.00	(−)0.500	(−)80.0	1.00	(−)160.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total		28.8		(−)51.2		(−)131.2				0.00		0.00		0.00		0.00		0.00
0.25	Shear Force	0.00	0.00	0.127 3	(−)2.546	0.299 6	(−)5.992	0.146 9	(−)2.938	0.0551	(−)1.102	0.025 5	(−)0.51	0.013 8	(−)0.276	0.008 4	(−)0.168	0.005 5	(−)0.11
	Direct Load	0.957 5	27.635	0.902 2	25.983 4	0.496 9	14.310 7	0.089 2	2.568 9	0.019 3	0.555 8	0.006 3	0.181 4	0.002 7	0.077 7	0.001 3	0.037 4	0.000 7	0.020 1
	Moment	0.000	0.00	0.387 5	(−)62.00	0.347 1	(−)55.536	0.060 4	(−)9.664	0.011 1	(−)1.776	0.003 1	(−)0.496	0.001 1	(−)0.176	0.000 5	(−)0.08	0.000 2	(−)0.032
	Total		27.635		(−)38.562 6		(−)47.217 3		(−)10.033 1		(−)2.322 2		(−)0.824 6		(−)0.374 3		(−)0.210 6		(−)0.121 9
0.50	Shear Force	0.00	0.00	0.156 7	(−)3.134	0.254 6	(−)5.092	0.210 7	(−)4.214	0.127 3	(−)2.546	0.073 9	(−)1.478	0.044 9	(−)0.898	0.028 9	(−)0.578	0.019 6	(−)0.392
	Direct Load	0.818 3	23.567 0	0.734 7	21.159 4	0.479 7	13.815 3	0.213 7	6.154 5	0.083 9	2.416 3	0.035 8	1.031	0.017 2	0.495 4	0.009 2	0.264 9	0.005 3	0.152 6
	Moment	0.00	0.00	0.210 6	(−)33.696	0.225 1	(−)36.016	0.109 9	(−)17.584	0.040 5	(−)6.48	0.015 5	(−)2.48	0.006 6	(−)1.056	0.003 1	(−)0.496	0.001 6	(−)0.256
	Total		23.567 0		(−)15.670 6		(−)27.292 7		(−)15.643 5		(−)6.609 7		(−)2.927		(−)1.458 6		(−)0.809 1		(−)0.495 4
0.75	Shear Force	0.00	0.00	0.127 3	(−)2.546	0.203 7	(−)4.074	0.202 2	(−)4.044	0.156 7	(−)3.134	0.109 8	(−)2.196	0.075 3	(−)1.506	0.052 4	(−)1.048	0.037 4	(−)0.748
	Direct Load	0.668 2	19.244 1	0.607 1	17.484 5	0.448 0	12.902 4	0.270 5	7.790 4	0.145 7	4.196 2	0.077 2	2.223 4	0.042 5	1.224	0.024 7	0.711 3	0.015 1	0.434 9
	Moment	0.00	0.00	0.112 5	(−)18.0	0.142 4	(−)22.784	0.102 4	(−)16.384	0.056 3	(−)9.008	0.028 4	(−)4.544	0.014 5	(−)2.32	0.007 7	(−)1.232	0.004 3	(−)0.688
	Total		19.244 1		(−)3.061 5		(−)13.955 6		(−)12.637 6		(−)7.945 8		(−)4.516 6		(−)2.602		(−)1.568 7		(−)1.001 1
1.00	Shear Force	0.00	0.00	0.095 9	(−)1.918	0.1 592	(−)3.184	0.175 4	(−)3.503	0.1567	(−)3.134	0.1254	(−)2.508	0.095 5	(−)1.91	0.071 7	(−)1.434	0.034 0	(−)1.08
	Direct Load	0.549 8	15.834 2	0.510 5	14.702 4	0.409 2	11.784 9	0.287 6	8.282 9	0.184 8	5.322	0.114 2	3.288 9	0.070 6	2.033 3	0.044 5	1.281 6	0.028 9	0.832 3
	Moment	0.00	0.00	0.063 5	(−)10.16	0.090 8	(−)14.528	0.080 7	(−)12.912	0.056 3	(−)9.008	0.034 9	(−)5.584	0.020 8	(−)3.328	0.012 4	(−)1.984	0.007 5	(−)1.20
	Total		15.834 2		2.624 4		(−)5.927 1		(−)8.137 1		6.820		(−)4.803 3		(−)3.204 7		(−)2.136 4		(−)1.447 7
1.25	Shear Force	0.00	0.00	0.072 0	(−)1.44	0.124 2	(−)2.484	0.146 9	(−)2.938	0.144 0	(−)2.88	0.126 5	(−)2.53	0.104 7	(−)2.09 4	0.084 1	(−)1.682	0.066 8	(−)1.336
	Direct Load	0.461 8	13.299 8	0.436 5	12.398 4	0.370 0	10.656	0.285 1	8.210 8	0.204 5	5.889 6	0.140 7	4.052 2	0.095 2	2.711 8	0.064 6	1.860 5	0.044 3	1.275 8
	Moment	0.00	0.00	0.038 7	(−)6.112	0.059 5	(−)9.52	0.060 4	(−)9.664	0.049 2	(−)7.872	0.035 4	(−)5.664	0.023 9	(−)3.824	0.015 8	(−)2.528	0.010 4	(−)1.664
	Total		13.299 8		4.846 4		(−)1.348		(−)4.391 2		(−)4.862 4		(−)4.141 8		(−)3.376 2		(−)2.349 5		(−)1.724 2
1.50	Shear Force	0.00	0.00	0.055 1	(−)1.102	0.097 9	(−)1.958	0.121 9	(−)2.438	0.127 3	(−)2.546	0.119 8	(−)2.396	0.105 8	(−)2.116	0.089 9	(−)1.798	0.074 9	(−)1.498
	Direct Load	0.395 8	11.399 0	0.379 1	10.918 1	0.334 1	9.622 1	0.273 5	7.876 8	0.211 2	6.082 6	0.156 8	4.515 8	0.113 9	3.280 3	0.082 1	2.361 5	0.059 3	1.707 8
	Moment	0.00	0.00	0.024 4	(−)3.900	0.040 3	(−)6.443	0.049 7	(−)7.152	0.040 5	(−)6.48	0.032 5	(−)5.20	0.024 3	(−)3.888	0.017 5	(−)2.80	0.012 3	(−)1.968
	Total		11.399 0		5.912 1		1.221 1		(−)1.713 2		(−)2.943 4		(−)3.080 2		(−)2.723 7		(−)2.236 5		(−)1.758 2
1.75	Shear Force	0.00	0.00	0.043 0	(−)0.86	0.078 4	(−)1.568	0.101 2	(−)2.024	0.110 8	(−)2.216	0.109 8	(−)2.196	0.101 9	(−)2.038	0.090 8	(−)1.816	0.078 8	(−)1.576
	Direct Load	0.345 3	9.949 6	0.333 9	9.616 3	0.302 4	8.709 1	0.258 3	7.439	0.210 2	6.053 8	0.165 0	4.752	0.126 6	3.646 1	0.095 9	2.761 9	0.072 3	2.082 2
	Moment	0.00	0.00	0.016 3	(−)2.608	0.028 1	(−)4.496	0.033 3	(−)5.328	0.032 6	(−)5.216	0.028 4	(−)4.544	0.023 0	(−)3.68	0.017 7	(−)2.832	0.013 3	(−)2.128
	Total		9.949 6		6.148 3		2.645 1		0.087		(−)1.378 2		(−)1.988 0		(−)2.071 9		(−)1.886 1		(−)1.621 8
2.00	Shear Force	0.00	0.00	0.034 3	(−)0.686	0.637	(−)12.74	0.084 5	(−)1.69	0.095 9	(−)1.918	0.098 8	(−)1.976	0.095 5	(−)1.910	0.088 4	(−)1.768	0.079 5	(−)1.590
	Direct Load	0.305 8	8.807 0	0.297 6	8.570 9	0.214 9	7.917 1	0.242 1	6.972 8	0.204 7	5.895 4	0.167 7	4.829 8	0.342	3.864 9	0.105 9	3.049 9	0.082 9	2.387 5
	Moment	0.00	0.00	0.011 4	(−)1.824	0.020 3	(−)3.248	0.025 1	(−)4.016	0.026	(−)4.160	0.024 1	(−)3.856	0.020 8	(−)3.328	0.017 0	(−)2.720	0.013 5	(−)2.16
	Total		8.807 0		6.060 9		(−)8.070 9		1.266 5		(−)0.182 6		(−)1.002 2		(−)1.373 1		(−)1.438 1		1.362 5

Sign Convention : (−) = Tensile stresses.
(+) = Compressive stresses.

Standard Mark

The use of the Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act, 1986* and the Rules and Regulations made thereunder. The Standard Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well defined system of inspection, testing and quality control which is devised and supervised by BIS and operated by the producer. Standard marked products are also continuously checked by BIS for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act, 1986* to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

Copyright

Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Handbook' and 'Standards Monthly Additions'. Comments on this Indian Standard may be sent to BIS giving the following reference:

Doc : No. RVD 10 (95)

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones : 331 01 31, 331 13 75

Telegrams : Manaksanstha
(Common to all Offices)

Regional Offices:	Telephone
Central : Manak Bhavan, 9 Bahadur Shah Zafar Marg NEW DELHI 110002	331 01 31 331 13 75
Eastern : 1/14 C. I. T. Scheme VII M, V. I. P. Road, Maniktola CALCUTTA 700054	37 84 99, 37 85 61 37 86 26, 37 86 62
Northern : SCO 445-446, Sector 35-C, CHANDIGARH 160036	53 38 43, 53 16 40 53 23 84
Southern : C. I. T. Campus, IV Cross Road, MADRAS 600113	235 02 16, 235 04 42 235 15 19, 235 23 15
Western : Manakalaya, E9 MIDC, Marol, Andheri (East) BOMBAY 400093	632 92 95, 632 78 58 632 78 91, 632 78 92

Branches : AHMADABAD. BANGALORE. BHOPAL. BHUBANESHWAR. COIMBATORE. FARIDABAD. GHAZIABAD. GUWAHATI. HYDERABAD. JAIPUR. KANPUR. LUCKNOW. PATNA. THIRUVANANTHAPURAM.

Printed at Printrade, New Delhi, India